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ORIGINAL ARTICLE

MODE OF FAILURE OF AMALGAM RESTORATIONS BONDED WITH RESIN ADHESIVE AND LIGHT CURE GLASS IONOMER LINER/BASE – A SEM STUDY

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ABSTRACT:
Objective: The objective of this study was to evaluate using Scanning Electron Microscope, the mode of failure of simulated bonded amalgam restorations in class V cavities, using a resin adhesive, Prime &Bond™ 2.0, and light cure glass ionomer liner/base, Vitrebond™, as the adhesive intermediary. **Methodology:** Twenty five extracted non carious molars were decoronated at the CEJ and mounted in aluminium tubes using autopolymerizing resin. Standard class V cavities were prepared with 2.5 mm depth and 3 mm width, with slightly divergent lateral walls and randomly divided into three groups. Group A and B, consisting of 10 teeth each, resin adhesive Prime & Bond™ 2.0, and light cure glass ionomer liner/base, Vitrebond™, were used as the adhesive intermediary, respectively, to bond amalgam restorations. Group C, consisting of five teeth, no adhesive intermediary was used and served as control. The specimens were loaded to failure in tension and observed under SEM to evaluate the mode of failure. **Results:** Group A in which resin adhesive Prime & Bond™2.0 was used as the adhesive intermediary showed adhesive failure at the resin amalgam interface in 80% samples. Group B in which light cure glass ionomer liner/base was used as the adhesive intermediary, showed a cohesive failure within the Vitrebond in majority(90%) of specimens. **Conclusion:** The results of the present study show that both, the resin adhesive, Prime & Bond™2.0 and light cure glass ionomer liner/base, Vitrebond, have the potential for being effective amalgam adhesives.
Keywords: Bonded amalgam, resin adhesive, light cure glass, SEM, mode of failure.

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INTRODUCTION:

Amalgam, one of the first direct restorative material, still remains the material of choice in restoration of posterior teeth, where there are significant occlusal forces. However, the major drawback of amalgam is that it lacks the ability to bond to tooth structure. Traditionally, dental amalgam restorations have been retained mechanically, by incorporating retentive features in the cavity design, necessitating the removal of healthy tooth structure.

Bonding amalgam to the tooth structure with adhesive intermediaries help ameliorate some of the deficiency of amalgam as a restorative material.

Recent advances in dentin adhesive system provided the opportunity to use dentin adhesives as intermediary to bond amalgam to the tooth. This would minimize microleakage at the tooth restoration interface and enhance retention without sacrificing sound tooth structure through the production of undercuts or the insertion of pins.[1,2,3.]

In appreciation of the fact that even restorations with adhesive materials always have microscopic spaces between them and the cavity walls, it would be sensible with bonded restorations to aim not only to minimize microleakage, but also to provide cavity walls with anticariogenic property.

The glass ionomer cements seem particularly suitable, as their ability to bond to enamel and dentin is well established, produce a good seal, and exert cariostatic effect as they leach fluoride,and have low coefficient of thermal diffusivity.[4,5.]The light cure glass ionomer liners appear to be the most appropriatefor these "bonded amalgam" restorations, as they achieve close to their maximum strength almost immediately after placement, saving several minutes of clinical time.In addition, a light cure glass ionomer liner (Vitrebond) has been shown to have a relatively high surface pH value compared to several chemical curing brands.[6] This may be of clinical relevance, especially in view of the concern that have been expressed regarding postoperative sensitivity that might have arisen as a result of acid pH during the setting of these materials.

Significant benefits can be envisaged, not only in saving of the tooth structure, but also in terms of reinforcement of tooth, increased retention of amalgam restoration, reduction in postoperative sensitivity , microleakage, secondary caries and corrosion, from the use of adhesive intermediaries , vis-a-vis amalgam. Very few studies have been carried out using SEM, to evaluate the mode of failure of bonded amalgam restorations.

Hence this study examines the mode of failure of amalgam restorations bonded with resin adhesives and light cure glass ionomer liner/base, using scanning electron microscopy.

AIM:

This in vitro SEM study is undertaken with the following objectives

1. To evaluate the mode of failure of simulated bonded amalgam restorations in class V cavities, using fifth generation Dentin Bonding Agent, Prime &Bond™ 2.0,as the adhesive intermediary.
2. To assess the mode of failure of class V bonded amalgam restorations using light cure glass ionomer liner/base, Vitrebond™, as the adhesive intermediary.
3. To compare the mode of failure of bonded amalgam restoration using resin adhesive (Prime & Bond 2.0) and light cure glass ionomer liner/base(Vitrebond) as the adhesive intermediary.

MATERIALS AND METHOD

Twenty five extracted non – carious, human molars, devoid ofdevelopmental defects wereselected for the study, from the Department of Oral&Maxillofacial Surgery, Pushpagiri College of Dental Sciences,Tiruvalla. The teeth were cleaned of debrii by hand scaling and stored in saline at room temperature, after extraction and between restoration and testing procedure.

The crowns were separated at the level of CEJ, using a carborundum disk in micromotorhandpiece, under a constant stream of water. The crowns were then mounted in autopolymerizing resin in aluminium tubes, to expose a flat facial, lingual or proximal enamel surface.

Each specimen were mounted on a bench vise, and a non – retentive class V cavity prepared with a carbide crosscut fissure bur (≠557, Ash, England), in a high speed dental handpiece with a water spray on the exposed facial, lingual or proximal surface. Each bur was used to prepare only 10 cavities. The preparations (Fig.1) were 2.5mm deep and 3 mm wide, with slightly divergent lateral walls, which ensured that the cavities were not undercut. The main advantage of this method was that it utilized a clinically relevant preparation that included both enamel and dentin.The prepared teeth were randomly divided into three groups, Group A and Group B, each comprising of 10 teeth and Group C, consisting of 5 teeth.

Group A: This group, color coded Red, fifth generation, light cure single component dentin bonding agent, Prime& Bond TM2.0(Dentsply Ltd, Surrey, UK), was used as the adhesive intermediary to bond amalgam restoration to tooth.

The cavity surface was etched for 20 seconds with 37% phosphoric acid, rinsed with water for 30 seconds, dried with gentle blasts of oil free air, taking care to avoid dessicating dentin. Prime & Bond 2.0 was dispensed onto disposable brush tip, applied onto the treated cavity surfaces, to thoroughly wet the exposed dentin and enamel, left undisturbed for 30 seconds, and light cured for 10 secondsusing LITEX 680, curing light unit(DENTAMERICA, California,91744).A second coat of Prime and Bond 2.0, was applied and left uncured.

Group B: This group color coded Green, received a light cured glass ionomerliner/base, VitrebondTM (3M, Dental Products, USA), as the adhesive intermediary for bonding amalgam to the tooth.

As per the manufacturers instruction, dentin was not pretreated. The liner cement was prepared by rapidly mixing (10 – 15 seconds) one level scoop of powder with two drops liquid on mixing pad with a plastic spatula. The mixed liner/base was applied to the cavity surface in a thin layer and left uncured.

Group C: This group was given Pink color and restored with amalgam without the use of an intermediary liner/base, and served as the control.

Following the preparations, a half inch, 18 – gauge flat headed nail was placed into the cavity with the head resting on the pulpal floor. A thin layer of cavity varnish (Nouava Dental Varnish, Mumbai)was applied to the nail head to prevent it from bonding to the adhesive intermediary. Dentfilloy, (DENTFILLS, Mumbai,India)was triturated in an amalgamator and the amalgam triturate was immediately condensed into the preparation and around the head of the nail, manually, with a small condenser using a standard clinical technique. The amalgam restorations were carved flush with the cavosurface; light was applied along the margins of the restorations to cure the adhesive intermediaries that may have flown to the cavosurface during condensation of the amalgam. The specimens were stored in saline for 24 hours at room temperature.

The amalgam restorations were polished after 24 hours with pumice and rubber cup in a slow speed handpiece. All the specimens were thermocycled in a water bath between 50C and 550C, alternatively100 times. After thermocycling the specimens were stored in saline at room temperature.

The specimens were attached to the Hounsfield Tensometer (Tensometer Limited, Croydon, England) and loaded to failure in tension at a crosshead speed of 2mm/minute.

SCANNING ELECTRON MICROSCOPY

Scanning electron microscopy was performed on all the samples from Group A ,B& C, after they were loaded to failure in tension in the Tensometer, to examine the mode of failure of bonded amalgam restorations. The specimens were washed with 5 ml of distilled water, sonicated in deionized water for 3 minutes and dessicated for 48 hours. Then specimens were sputter coated for 3 minutes with gold using a sputter coater (fig.5). The cavity surface and the intaglio surface of the amalgam restoration of each specimen was analyzed using SEM to evaluate the failure mode and was recorded.

Figure 1: Materials used in the study

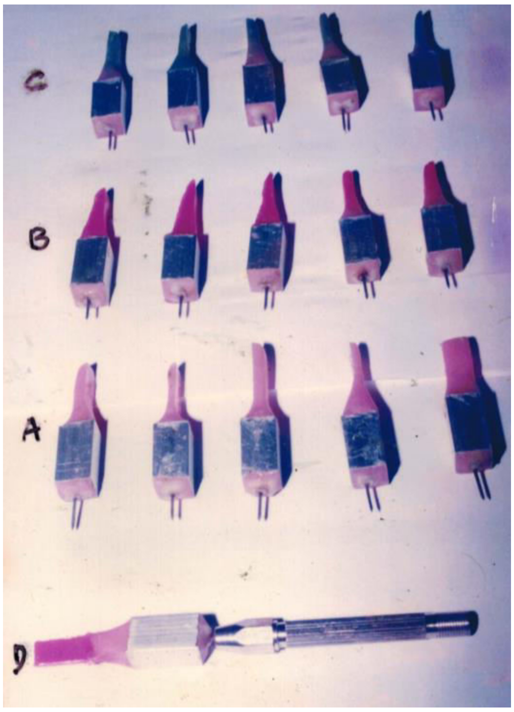

Figure 2: Prepared teeth samples. **A)** Pink denotes control samples (Group C); **B)** Red denotes samples resorted with resin adhesive, Prime & Bond 2.0 (Group A); **C)** Green denotes samples restored with light cure glass ionomer liner/ base, Vitrebond (Group B). **D)** Sample fastened to pin vase

Figure 3: Armamentarium

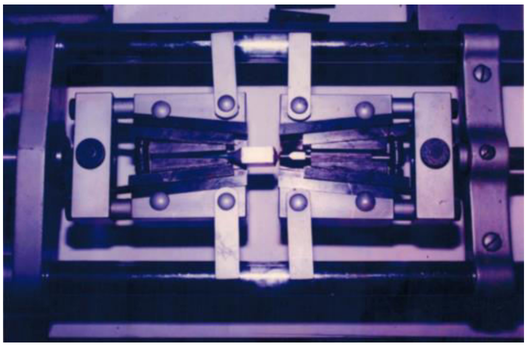

Figure 4: Sample mounted in the Tensometer

Figure 5: Gold sputter coated sample

RESULTS: The simulated class V bonded amalgam restorations were loaded to failure in tension, in a Hounsefield Tensometer, and fractured surfaces of the teeth and the amalgam restorations were examined under Scanning Electron Microscope and the mode of failure was tabulated as in Table 1.

Table 1: Mode of failure of amalgam restorations

Groups	Adhesive failure	Cohesive failure
A	8	2
B	1	9
C	5	0

Group A, in which Prime & Bond was used as the adhesive intermediary predominantly, showed adhesive failure(80%) at the resin amalgam interface (fig.6).Two specimens exhibited cohesive failure within the amalgam restoration.SEM examination of the amalgam surface showed virtually no resins or resin in patches on the amalgam(fig.6).

Group B in which light cure glass ionomer liner/base was used as the adhesive intermediary, showed a cohesive failure within the Vitrebond (fig.7) in majority (90%) of specimens while one sample exhibited adhesive failure at the glass ionomer amalgam interface. SEM examination of the amalgam surface showed a uniform veneer of glass ionomer liner/base, (fig.7) smeared over the amalgam.

Group C in which no adhesive intermediary was used showed adhesive failure in all samples (100%) at tooth amalgam interface.

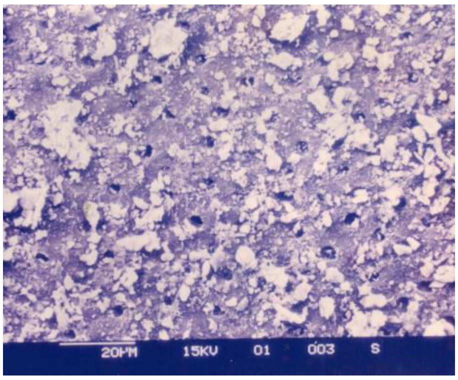

Figure 6: SEM micrograph showing tooth surface, restored with Prime & Bond 2.0, after bond failure

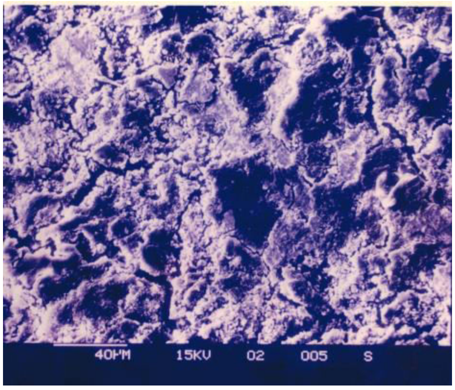

Figure 7: SEM micrograph of the amalgam surface restored with Prime & Bond 2.0 after bond failure

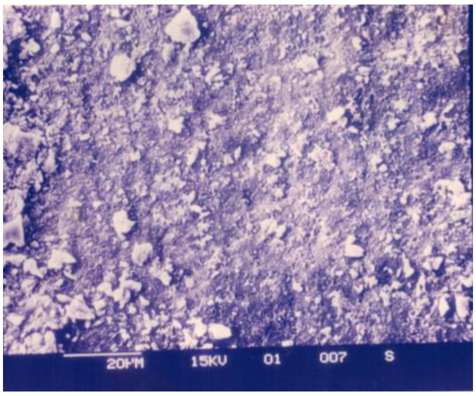

Figure 8: SEM micrograph of the tooth surface restored with light cure glass ionomer liner/ base following bond failure

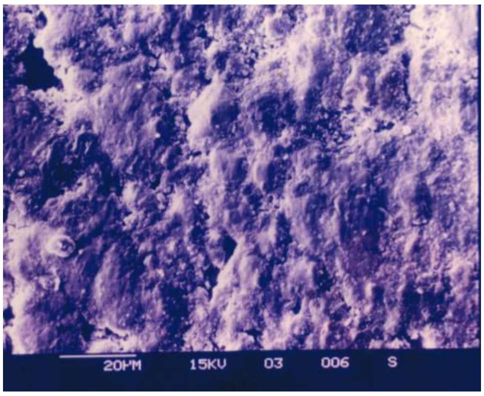

Figure 9: SEM micrograph of the amalgam surface restored with light cure glass ionomer liner/ base following bond failure

DISCUSSION:

The amalgam alloy still remains the most widely used filling material in restorative dentistry, especially, in large posterior restorations subject to heavy occlusal forces. Although it possesses excellent physical properties, lack of adhesion to the tooth structure has been the major drawback of amalgam. Marginal microleakage and its attendant sequel of secondary caries and pulp pathology have also been a serious clinical problem. Consequently, researchers have been looking for dental amalgam bonding alternatives.

Aiding the retention of amalgam with phosphate cement was advocated in the 1920s and was known as Baldwin technique. The treatment of enamel surface with phosphoric acid, introduced by Buonocore in 1955, provided the first generation bonding agents.In 1983, Zardiackaset al, established the concept of bonding amalgam to tooth structure. Since then various materials have been used to bond amalgam to tooth structure in vitro and in vivo and the consensus seems to be that adhesive resins are the material of choice.[1]

Many researchers[3,7,8,9] have shown that it is possible to bond amalgam triturate to the cavity wall and liners. This would minimize microleakage, enhance retention and allow an increase in bulk (and hence the strength) of amalgam without requiring additional removal of tooth structure. Micromechanical locking has been proposed as the bonding mechanism between amalgam and adhesive resin.[10]In addition, it is also speculated that chemical interactions take place between the amalgam and the adhesive resin.[9,10]

In appreciation of the fact that even restorations with adhesive materials always have microscopic spaces between them and the cavity walls, it would be advantageous to use materials that not only reduce microleakage but also provide cavity walls with anticariogenic property. Glass ionomer cements might fulfil this criterion.

Glass ionomers are increasingly used as liners/bases under amalgam restorations as they leach fluoride, bond to dentin, and have a low coefficient of thermal diffusivity.[11]The light cure glass ionomer liners are more suitable for bonding amalgam as they rapidly achieve near maximum strength.In addition, the light cure glass ionomer liner, Vitre bond, used in the present study has been reported to have a relatively high surface pH,[6]and exhibits higher bond strengths to tooth, compared with chemically curing brands.

Aboush and Elderton(1991)[5,12]showed that strong reliable bond can be achieved between uncured vitrebond intermediary and amalgam. They suggested that amalgam -glass ionomer bonds are probably the result of mechanical interlocking of the amalgam triturate and the glass ionomer cement; and ionic exchange at the interface cannot be excuded. Also, the glass ionomer liners provide additional thermal insulation for the dental pulp and offers potential for fluoridation of tooth structure, increasing its resistance to recurrent caries, particularly if the restoration should fail.[9]

This study was undertaken to evaluate using Scanning Electron Microscope, the mode of failure of simulated bonded amalgam restorations in class V cavities in extracted teeth using a resin adhesive, Prime & Bond^{TM} 2.0, and a light cure glass ionomer liner/base, Vitrebond^{TM}, as the adhesive intermediary. Restorations placed without any intermediary served for comparison purposes. After thermocycling, the amalgam restorations were loaded to failure in tension at a crosshead speed of 2mm/minute, using a Hounsfield Tensometer and the fractured tooth surface and the intaglio surface of amalgam restoration were evaluated with SEM to assess the mode of failure.

Group A in which resin adhesive Prime & Bond^{TM}2.0was used as the adhesive intermediary showed adhesive failure at the resin amalgam interface(fig.6) in 80% samples.SEM examination of the amalgam surface showed virtually no resin or resin in patches, on the amalgam(fig).This mode of adhesive failure at the resin amalgam interface has been reported by Santos & Meiers, 1994[8]and McComb et al , 1995[13]and Al Moayad et al 1993[14].Ratananakin and others,1996[15]examined experimentally fractured surfaces of amalgam bonded to dentin and revealed that most failures were adhesive, occurring along the dentin-amalgam interface.

Group B in which light cure glass ionomer liner/base was used as the adhesive intermediary, showed a cohesive failure within the Vitre bond (fig.7) in majority(90%) of specimens except one sample,which exhibited adhesive failure at the glass ionomer amalgam interface.SEM examination of the amalgam surface showed a uniform veneer of glass ionomer liner/base,(fig.7)smeared over the amalgam. This indicates that the bond achieved between the glass ionomer and tooth structure at one side, and between the glass ionomer and amalgam at the other, is stronger than the cohesive strength of the glass ionomer itself. This mode of cohesive failure is favourable in that the dentinal tubules remain occluded thereby negating postoperative sensitivity, and pulp pathology, if the restoration were tofail. Glass ionomers with their fluoride releasing property, would protect the tooth from the decalcifying activity of caries producing bacteria. Aboush & Elderton 1991[5,12] and Al Moayad et al 1993[14] reported a cohesive failure when Vitrebond was used as the adhesive intermediary in bonding amalgam.

The results of the present study show that light cure glass ionomer liner/base, Vitrebond, has the potential for being an effective amalgam adhesive. Caution should be used in applying these results to practice as this was a laboratory experiment that attempted to duplicate clinical situation. Normal masticatory stresses may have an entirely different effect on the adhesive bond and also influence the long term stability of the bonding mechanism. However, the early research and the known properties of the materials involved offer promise for the concept of bonded amalgam restorations.

CONCLUSION:

The amalgam restorations bonded with resin adhesive Prime & Bond^{TM}2.0 showed adhesive failure (80%) at the resin amalgam interface. 0The amalgam restorations with glass ionomer as the adhesive intermediary exhibited cohesive failure (90%) within the glass ionomer. The results of the present study show that both the resin adhesive, Prime & Bond^{TM}2.0 and light cure glass ionomer liner/base, Vitrebond, have the potential for being effective amalgam adhesives. However, the inherent properties of fluoride release and anti-cariogenicity gives the glass ionomer liner/base, an obvious advantage. Further studies in stress bearing areas, where amalgam is used more frequently are needed to shed better light into the behaviour of bonded amalgam restorations.

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